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A LASER WELDING METHOD AND A LASER WELDING APPARATUS

Background of the Invention

1) Field of the Invention:

This invention relates to a laser welding method and a laser welding apparatus, particularly to a laser welding method and a laser welding apparatus using a small laser welding head which can precisely weld bodies to be welded in a good quality without an entire gas shielding for the bodies.

2) Description of Related Art:

Recently, with the advance of high-power laser welding technique, a high-power CO_2 laser welding technique is used for a macro welding, and a YAG laser welding technique is used for a precise welding. The reason is that the above techniques have the following advantages, in comparison with other welding techniques such as a TIG welding technique and a MIG welding technique.

(1) Large welding ratio (welding depth/melting bead width), and small processing strain

(2) High speed welding, and being capable of providing a high quality welded joint through little remaining thermal efficiency and repressing the increase of crystalline grains

(3) Being capable of performing a welding process in a canister with a transparent window having a peculiar atmosphere therein

(4) Being capable of welding different kinds of metal or a metal and a non-metal

Moreover, the above techniques have the following advantages, in comparison with an electron beam welding technique.

(5) Not be influenced by the magnetic field of bodies to be welded, and

thus, being capable of welding a magnetic material

(6) Not requiring a vacuum chamber and a X-ray shielding.

On the contrary, in the above-mentioned laser welding technique, the melting part of the bodies to be welded is chemically reacted to an atmosphere gas around the bodies, and particularly, if the melting part is oxidized by a nearby air, the weld bead is disadvantageously degraded. As a result, a coaxial nozzle is attached to the laser welding head, and thus, for preventing the oxidization of the melting part, a shielding gas such as Ar gas or He gas is blown on a part to be welded of the bodies to be welded, which corresponds to the melting part, at the same time when a converged laser is irradiated to the part to be welded.

However, even if the shielding gas is blown on the part to be welded, the melting part often chemically reacts, and thus, is often oxidized. As a result, an exogenous material is generated at and taken in the welded part of the bodies to be welded through the chemical reaction and the oxidization, resulting in the degradation of the welded part.

Consequently, for preventing the above chemical reaction and oxidization, it is obliged to perform the laser welding process in a steel case having a shielding gas to prevent the oxidization (chemical reaction) after the steel case is evacuated. On account of this process, a large-scale and complicate laser welding apparatus is needed.

Furthermore, the above shielding gas may be partially taken in the weld bead by a large amount, so that, if the welded body is employed under an ultra-high vacuum atmosphere of not more than 10^{-5} Pa or a hyperultra-high vacuum atmosphere of not more than 10^{-9} Pa, the partially taken-in shielding gas is gradually emitted, resulting in the degradation of the vacuum degree.

Summery of the Invention

It is an object of the present invention to bring out the advantages and characteristics of the above laser welding by ironing out the above-mentioned matters, that is, to provide a laser welding method and a laser welding apparatus which can prevent the oxidization and the chemical reaction of the welded part of the bodies to be welded by shielding parts to be welded of the bodies perfectly from an outside air and maintaining the shielded atmosphere, and can reduce the shielding gas emission from the weld bead for the welded body be able to be employed in such an ultra-high vacuum atmosphere or a hyperultra-high vacuum atmosphere.

For achieving the above object, this invention is directed at a laser welding method for welding plural bodies to be welded comprising the steps of:

blowing an inert gas on a part to be welded from a coaxial nozzle,

blowing a compressed shielding gas around the part to be welded so as to cover the inert gas from at least one discharging nozzle provided at the outer side of the coaxial nozzle, and

irradiating a converged laser onto the part to be welded, and thus, melting the part under the shielded condition from an outside air to weld the plural bodies.

Moreover, this invention is directed at a laser welding apparatus for welding plural bodies to be welded comprising:

a coaxial nozzle to blow an inert gas on a part to be welded,

at least one discharging nozzle, provided at the outer side of the coaxial nozzle, to blow a compressed shielding gas around the part to be welded so as to cover the inert gas,

a laser oscillator to oscillate a laser, and

a condenser to converge the laser, and thus, melt the part to be welded through the irradiation of the converged laser under the shielded condition from an outside air to weld the plural bodies.

The other objects, configurations and advantages will be explained in detail, with reference to the attaching drawings.

Brief Description of the Drawings

For better understanding of the present invention, reference is made to the attached drawings, wherein

Fig. 1 is a perspective view schematically showing a welding head in the laser welding apparatus of the present invention,

Fig. 2 is a cross sectional view schematically showing the nozzle of the welding head shown in Fig. 1,

Fig. 3 is an elevational view of the nozzle shown in Fig. 2, taken on line "3-3", and

Fig. 4 is a cross sectional view showing another nozzle of a welding head in the laser welding apparatus of the present invention.

Description of the Preferred Embodiments

This invention will be described in detail with reference to figures.

Fig. 1 is a perspective view schematically showing a welding head in the laser welding apparatus of the present invention, and Fig. 2 is a cross sectional view schematically showing the nozzle of the welding head shown in Fig. 1. Fig. 3 is an elevational view of the nozzle shown in Fig. 2, taken on line "3-3", and Fig. 4 is a cross sectional view showing another nozzle of a welding head in the laser welding apparatus of the present invention.

A laser welding head 1 depicted in Fig. 1 has a condenser 2 as an optical system to converge a laser 4 and a nozzle 3. In Figs. 1-4, the

laser 4 travelling in an arrow y direction passes through the condenser 2, and focuses on a part 5b to be weld between two bodies 5 (bodies 5-1 and 5-2 in Fig. 1) to be weld or the nearby area to form a focused spot 4sp. In this embodiment, the two bodies 5-1 and 5-2 are welded, but three or over bodies may be welded. Moreover, in this embodiment, the part 5b to be welded exists alongside a welding line X. Instead of the condenser 2, an optical mirror system may be employed.

The nozzle 3 has a coaxial nozzle 6 at its center. The coaxial nozzle 6 serves as a converged laser-discharging hole for the part 5b to be welded between the bodies 5-1 and 5-2 to be welded and a cylindrical compressed inert gas-discharging hole, and can match the axes Y_1 and Y of the converged laser and the discharging holes substantially.

Moreover, the nozzle 3 has at least one discharging nozzle 7 around the coaxial nozzle 6. The discharging nozzle 7 discharges a compressed shielding gas for the part to be welded. In Figs. 2 and 3, one discharging nozzle 7-1 is provided, and in Fig. 4, two discharging nozzles 7-1 and 7-2 are provided.

Next, the operation of the laser welding head 1 will be described hereinafter.

During the welding, the laser 4, which is oscillated from an oscillator such as a CO_2 laser oscillator or a YAG laser oscillator generally provided on the laser welding apparatus, is converged via the condenser 2, and the converged laser 4f is irradiated on the part 5b (along the welding line X) to be welded between the bodies 5-1 and 5-2 to be welded through the coaxial nozzle 6 serving as the above discharging holes. In this case, the focusing spot 4sp is positioned slightly above the position 5b.

At the same time, a compressed inert gas Ig_1 having a regulated

gauge pressure p_1 is discharged cylindrically for the part 5b in an arrow direction, and compressed shielding gases Ig_2 and Ig_3 having regulated gauge pressures p_2 and p_3 are discharged in laminar flow for the position 5b in arrow directions.

Just then, as shown in Figs. 2 and 4, the shielding gases Ig_2 and Ig_3 cover the inert gas Ig_1. Therefore, the discharging nozzle 7 is preferably provided coaxially for the coaxial nozzle 6. Moreover, in this case, it is desired that the gases Ig_1-Ig_3 are discharged in constant flow. And then, it is also desired that the regulated gauge pressures p_1-p_3 satisfy the relation of $p_1>p_2\geq p_3$. Herein, the states of the inert gas and the shielding gas between the nozzle 3 and the bodies 5 to be welded are depicted by the respective solid lines.

The shielding gases Ig_2 and Ig_3 discharged from the nozzle 3 form a strong barrier with the inert gas Ig_1 around the part 5b to be welded against an outside air, and the gases Ig_1-Ig_3 are discharged outside after they arrives at the position 5b or the nearby area. Therefore, gases to chemically react with the position 5b, particularly to oxidize the position 5b can be removed from the nearby area.

As a result, oxides or other compounds can not be generated at the position 5b and the formation of spatter can be repressed, so the welding can be performed in good condition. Moreover, since the shielding is performed locally around the position 5b, the welding head can be downsized extremely, and thus, the manufacturing cost can be decreased because another apparatus is not needed. Furthermore, on account of the small size of the welding head, even very small body to be welded can be precisely welded in high quality.

Moreover, it is desired that the nozzle 3 has an evacuating nozzle 8 in the outside of the discharging nozzle 7 having a decompressed

pressure p. In the case of that the two discharging nozzle 7 are provided as shown in Fig. 4, the evacuating nozzle 8 is provided between the inner and the outer discharging nozzles 7-1 and 7-2. The above shielding gas and the inert gas Ig_1-Ig_3 are evacuated by the evacuating nozzle 8 when they are discharged.

Thereby, these gases are made flown smoothly around the position 5b to be welded, so that the position 5b can be more effectively shielded from the outside air. And more, because of the smooth flow, the shielding gas or the like are prevented from diffusing to and contaminating the position 5b to be welded.

Although the evacuating nozzle 8 may be arranged at any positions around the coaxial nozzle 6, it is advantageous that it is arranged in the outside of the discharging nozzle 7 as shown in Figs. 2 and 3. Then, in the case of that the two discharging nozzle 7-1 and 7-2 are provided as shown in Fig. 4, it is advantageous that the evacuating nozzle 8 is arranged therebetween. In the latter case, the position 5b to be welded can be more effectively shielded against the outside air. The arrangement of the evacuating nozzle 8 is determined on the required shielding level.

The evacuating nozzle 8 is preferably arranged so that its axis can correspond with the axes of the coaxial nozzle 6 and the discharging nozzle 7 for shielding the position 5b to be welded against the outside air effectively.

Moreover, due to the similar reason, at least the discharging hole of the discharging nozzle 7 and the evacuating hole of the evacuating nozzle 8 have preferably cylindrical shapes, respectively. And at least the discharging hole of the coaxial nozzle has preferably columnar shape. As the above-mentioned gases Ig_1-Ig_3, an inert gases

such as N_2 gas, Ar gas or He gas may be employed.

As mentioned above, for shielding the position 5b to be welded against the outside air, the relation of $p_1 > p_2 \geq p_3$ is preferably satisfied. The welding operation is performed continuously along the welding line X at a speed v.

Although the present invention was described in detail with reference to the above examples, this invention is not limited to the above disclosure and every kind of variation and modification may be made without departing from the scope of the present invention. For example, using the laser welding apparatus having the above-mentioned plural welding heads, a good quality simultaneous multi-point spot welding can be performed precisely. Moreover, if the power of the laser 4 is adjusted, a superposing welding and a deep welding may be performed.

As mentioned above, according to the present invention, since the position to be welded can be shielded against the outside air, it is protected from the chemical reaction thereof with the composition such as oxygen. Therefore, the laser welding method and the laser welding apparatus of the present invention can be employed for an ultra-high vacuum vessel to attain a vacuum degree of not more than 10^{-5} Pa, a hyperultra-high vacuum vessel to attain a vacuum degree of not more than 10^{-9} Pa, a Mott scattering apparatus or a small urtraprecise instrument used in an ultra-high vacuum atmosphere.